A brief overview and studies analysis focus on the methods of monitoring the functional status of athletes practicing martial arts

Aleksander Osipov[1,2,5], Mikhail Kudryavtsev[1,3,4,5], Tatyana Zhavner[1], Oleslav Antamoshkin[1,3,6], Sergey Sitnichuk[4]

[1]*Siberian Federal University, Russia*
[2]*Professor V.F. Voino-Yasenetsky Krasnoyarsk State Medical University, Russia*
[3]*Reshetnev Siberian State University of Science and Technology, Russia*
[4]*Krasnoyarsk State Pedagogical University of V.P. Astafyev, Russia*
[5]*The Siberian Law Institute of the Ministry of Internal Affair of Russia, Russia*
[6]*Krasnoyarsk State Agrarian University, Russia*

Corresponding author: Aleksander Osipov, Siberian Federal University, e-mail: ale44132272@yandex.ru

ABSTRACT:
Study aim. Modern competitive activity imposes significant requirements of the functional readiness level of martial arts athletes. Moreover, informative and objective monitoring methods should be used for a qualitative assessment of the functional status of martial artists. At the same time, a single position on determining the most effective methods for monitoring the functional status of athletes practicing martial arts has not been developed by scientists. It was revealed that different specialists use various methods of monitoring and assessing the functional state of martial artists.
Indeed, the purpose of the research is a structural analysis of scientific research focuses on the methods of monitoring the functional status of athletes practicing martial arts carried out by scientists from Russia and several CIS countries.
Methods. Information search was carried out in scientific databases: SCOPUS, Web of Science, PubMed, Google Scholar, Crossref, eLIBRARY. Fortunately, searches included the words: functional training of athletes, martial arts, adaptation, monitoring, control. The recommendations of the PRISMA-P protocol were used to work with the data. Accordingly, the following criteria were taken into account when analyzing the data: achieving the goal of research, availability of sufficient number of studied athletes, availability of informative tests and measurements, statistical data analysis, age of documents not older than 8 years.
Results. There are 136 documents matching your search criteria. Besides, there are submitted documents: 124 articles and 12 PhD thesis. Furthermore, the most of the scientific papers (107 documents) are publications in Russian oriented to the Russian-speaking category of readers. Most of the documents (127 studies) contain data on the assessment of the functional state of martial artists using various methods. Besides, a number of studies (9 scientific papers) in addition to monitoring the functional status of athletes contain data on the restoration of the functional status of martial art wrestlers using various methods. The duration of studies had been from 1-2 days to 2 years. Moreover, the age of the studied athletes was from 6 to 30 years old. Sports practice of athletes: freestyle and Greco-Roman wrestling, judo, sambo, combat sambo, mixed martial arts (MMA), taekwondo, boxing, kickboxing and Muay Thai. However, there are objective and subjective methods for monitoring the functional status of athletes in the documents. Also, Russian scientists use hemodynamic and biochemical methods, use special fitness tests and conduct a comprehensive functional diagnosis of athletes.
Conclusions. Many monitoring methods of the functional state of martial artists (biochemical, physiological, special fitness tests) used by the Russian scientists are relevant and welcomed by the foreign experts. Some research methods limitations of biochemical indicators of the athletes' body's response to the load was revealed. The views focus on the methods of analyzing the data of heart rate variability of athletes are different evaluating their response to stress. A lack of monitoring data of the functional status of young athletes where athletes age is over 30 years old, girls and women practicing martial arts has been discovered. The research priority of the Russian scientists is young elite athletes reaching the age 17-22 years old, candidates and members of the national teams of the Russian Federation in various types of martial arts. An analysis of the documents has showed that Russian scientists are not using enough data from studies of foreign colleagues. The number of current references to the studies of foreign scientists in the literature is small. The lack of modern scientific data can have a negative impact on the quality of studies of the functional status of athletes practicing martial arts in the Russian Federation.
KEY WORDS: Martial arts, special endurance of athletes, training load, electrocardiogram (ECG), adaptation, biochemical parameters, scientific data, structural analysis.

INTRODUCTION

It is known that the modern competitive activity is characterized by a significant amount of training loads and strict requirements for the level of functional readiness of athletes. Effective organization of training activities requires quality control of the training process for athletes. By the way, specialists use various options for monitoring the physical status of athletes (objective and subjective) for control. Monitoring is necessary for optimal control of the training load and identification of any negative effects on the health of athletes [1]. The problems of

qualitatively monitoring of the training and competitive load of athletes are today a current topic of scientific research in the world. A significant increase has been found in empirical and applied research on this topic [2]. Today, sports doctors and trainers must comprehensively monitor all physiological changes in the body of athletes to create optimal training cycles. These cycles should contribute to maximizing greater productivity of athletes with minimal risk of overtraining and injury [3].

Nevertheless, the functional readiness level of athletes practicing martial arts is an essential component of their physical condition and readiness to achieve a sporting result. The need to achieve high competitive results makes coaches all the time to increase the volume and intensity of training loads which leads to a high stress degree of the body adaptation mechanisms of athletes [4]. Qualitative analysis and an objective assessment of the adaptive capacity of athletes are important factors in athletic selection and training activities of martial arts [5]. At the same time, experts point out that it is necessary to take into account all adaptation peculiarities of athletes to physical loads when planning the training process [6]. It is known that with high-intensity training effects, the lack or absence of control over the magnitude of the load leads to fatigue and the appearance of negative cross-effects of the body adaptation of martial arts [7]. In modern sports practice it is necessary to use informative and effective methods of monitoring and assessing the level of load received by athletes in the process of training activity [8]. Consequently, scientists point out that the qualitative monitoring of the physical and functional state of martial artists will be effective on the basis of comprehensive and systematic studies characterizing the different stages of the training process [9]. Experts also indicate that the results of such studies should be presented in the form of surveys used as reference materials in assessing the effectiveness of training programs and the physical status of athletes [10].

Besides, the purpose of the study is a qualitative structural analysis of modern scientific data focus on methods for monitoring the functional status of athletes practicing various types of martial arts. Scientific studies data of experts from Russia and several CIS countries had been used for the analysis.

METHODS

By the way, a search was made for significant (published in peer-reviewed scientific journals) documents in various scientific databases: Web of Science, SCOPUS, PubMed, Crossref, Google Scholar, eLIBRARY to achieve the study goal. Searches had included the terms: functional training, functional status, martial arts, athletes, monitoring, control, exercise, adaptive capacity, endurance. Consequently, the implementation recommendations of the review protocols and meta-analysis PRISMA-P were used to improve the review and analysis quality of the obtained data. The age of the found documents was not older than 8 years (2011-2019). The following criteria had been taken into account analyzing the data: the relevance of the research goal, the achievement of the stated research goal by the authors, a sufficient sample of studied athletes, the availability of informative tests and other measurements and a statistically correct analysis of the obtained data.

STATISTICAL RESULTS

Moreover, during the data search, 136 studies had been found that met all the criteria of the search request. Data were presented: 124 articles (there were 18 articles in the SCOPUS database, 13 articles in the Web of Science database and 93 articles in the databases: Crossref, Google Scholar, eLIBRARY) and 12 candidate dissertations (PhD thesis). At the same time, most of the found documents (107 papers) were publications in Russian aimed at the Russian-speaking audience of specialists. Only a small part of these studies (8 documents) had a full translated version in English. Most of the research (127 documents) was an assessment of the functional state of martial arts in a certain period of the training cycle. In addition, a number of studies (9 works) to assessing the level of the functional state of athletes had contained data on the possibility of restoring the functional status of martial art wrestlers by various methods. The age of the studied athletes was from 6 to 30 years. The studies duration was from 1-2 days to 2 years. The studied athletes had practiced: Muay Thai, taekwondo, judo, sambo, combat sambo, freestyle and Greco-Roman wrestling, boxing, kickboxing, mixed martial arts (MMA). All studied athletes were male. The sportsmanship level was varied: from athletes who did not have significant sporting achievements to Honored Masters of Sports (winners and prize-winners of world championships and Olympic Games). The majority of martial artists (72.6% of the studied athletes) were elite athletes who had an experience in competitive practice and sporting results in competitions at the national level. The scientists had used diagnostic (functional tests and tests), biochemical methods (determination of the level of lactate, creatine and other substances in the blood of athletes, the concentration of various substances in saliva) and various analyzing methods of heart rhythm variability of martial arts to assess the level of functional status of athletes. Also the widespread use of various tests was revealed to determine the level of special endurance of athletes to perform competitive load.

Data number of studied athletes are presented in Figure 1.

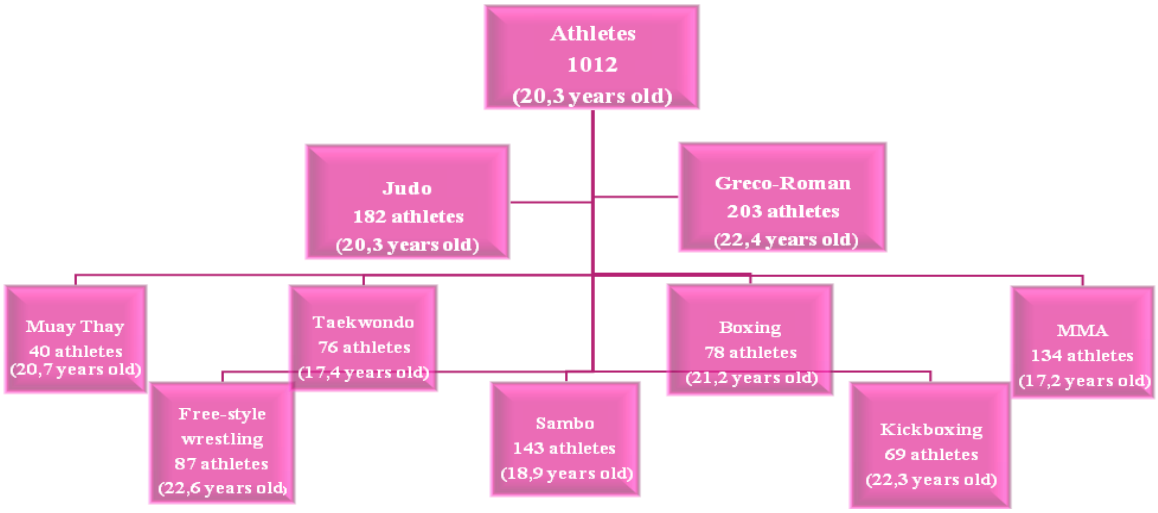

Figure 1. *Data about studied martial artists*

The main data of the studies presented in the overview are presented in Table 1.

Table 1: *General research characteristics*

Monitoring and recovery methods	Studies range	Outcomes
Heart rate, ECG, GDV-gram	31 Ar, 5 Cd (Ru-29, En-7)	The use of various methods of cardiointervalography has been identified: method of Bayevsky, method of Zavyalov, method of Dushanin
PWC_{170}, Harvard step test, Gench test, Stange test, Ruffer test, Cerdo test, etc.	35 Ar, 2 Cd (Ru-27, En-10)	Test results depend on the age and level of athletic achievement of athletes. Athletes who show high level results demonstrate higher levels of functional readiness.
Biochemical data: the level of lactate, creatine, the content of reticulocytes and hemoglobin in the blood, the ions concentration of K + and Na + in saliva, etc.	28 Ar, 3 Cd (Ru-24, En-7)	Some discrepancies were found in the assessment of blood lactate concentration data in determining the functional status of martial arts (from 22,7 to 24,8 mmol/l)
Special tests (SJFT, power test, etc.)	16 Ar, 1 Cd (Ru-13, En-4)	The dependence of the test results on the level of the functional state of martial artists has been revealed
Evaluation of technical and tactical actions and the activity level of athletes in competitive matches	5 Ar (Ru-3, En-2)	A high level of activity correlates with the level of functional readiness in competitive matches.
Transcranial stimulation, electromyogram, nutritional supplements	9 Ar, 1 Cd (Ru-9, En-1)	The adaptive capacity increase of athletes during the period of pre-competitive training, the level of hemoglobin increase and the level of cortisol reduction

Note: Ar - Article, Cd - PhD thesis, Ru - Russian text publication, En - publication in English

A brief overview of received findings

Consequently, the analysis of the found documents had revealed that scientists from Russia and the CIS countries use various objective and somewhat subjective methods to assess the functional status of martial artists. Romanenko et al., had used the definition of the dynamics of heart rate (HR) of 63 athletes practicing various types of wrestling and shock martial arts. At the same time, age of athletes was 17-18 years old. The results had shown that the adaptation degree to the load for all athletes was within the normal range. Scientists say that the dynamics of HR is the fastest and most easily recorded response of the body to training effects [11]. It goes without saying that Doeva and Gagieva propose to assess the functional state of martial arts by calculating the coefficient of endurance. This coefficient represents the integral indicator of the ratio of HR and pulse pressure. Scientists has examined 10 elite free-style wrestlers at rest, at the peak of the training load and during the recovery period: 1,2,3,5,7 and 10 minutes of the recovery period. However, experts say that endurance coefficient can be used to predict the athletic performance of athletes [12]. Many Russian specialists use the cardiointervalography method (heart rate variability analysis) to assess the functional state of the body of martial artists. Vikulov et al. had investigated 33 elite wrestlers of Greco-Roman style (the age of athletes was 18-23 years old). The recovery period after the last workout was 22-24 hours. Athletes had a 5-minute ECG recording. Data evaluation was performed by the method of Bayevsky. The data had shown the presence of normocardia – 63,82±8,69 beats/min. and moderate bradycardia – 58,26±7,22 beats / min. among the studied athletes. Scientists propose to use these indicators to assess the level of the functional state of elite wrestlers [13]. Besides, Osipov et al. had tested 90 elite athletes practicing martial arts (sambo, combat sambo, judo). ECG recording method of Zavyalov was used to assess the level of functional readiness of athletes. This method was based on assigning certain points to various electrocardiogram readings. The ECG assessment had taken into account the percentage of the number of ischemic ST segments and the presence of a plateau on the ECG. The criterion for acute fatigue was the presence of ischemic ST segments in 50-80% of the electrocardiogram complexes. These ECG readings were estimated at 26-28 points and serve as a criterion for reducing or stopping the training load. The results had showed a significant advantage of athletes using this method in the development of special endurance [14]. Grishin et al, had used the ECG recording method of Zavyalov to control the functional status of elite kickboxers (19-21 years old). It was found that athletes who used this method not only differed in the best performance indicators, but also they had significantly reduced the percentage of the fat component of body weight from 11–12% to 7–9% [15]. Portnyagin et al., had used to assess the dynamics of the functional state of the cardiovascular system of martial artists, the method of recognition and measurement of R-R time intervals of the electrocardiogram followed by the analysis of numerical series by mathematical methods. For evaluation, the Omega-S software and hardware complex (manufactured in Russia) was used. The study had been conducted with 20 elite freestyle wrestlers for 3 weeks. The use of this method had been recognized as effective in addressing issues of operational control and an objective assessment of the level of functional readiness of athletes [16]. Zebzeev et al, had conducted a development dynamics study of special endurance of 40 elite judo wrestlers (17-19 years). The research duration was during 2 years. We had used the Omega-S software and hardware complex (made in Russia) and the multifactorial express diagnostics of the ECG recording method of Dushanin. It was revealed that the athletes who used this method while controlling the training load had a special level of endurance increased significantly during the research. A significant increase of lactate concentration in the blood to 24.2-24.8 mmol / l and an increase in the maximum oxygen consumption up to 90% had been found [17]. Minko had used ECG readings and the PWC170 test to study the level of adaptive responses of martial artists to the load. 64 athletes (17-21 years old) practicing sambo and judo were studied. ECG registration was carried out at rest and after a training load. It was revealed that the worst indicators of the body's adaptive response to physical activity predominate among athletes of younger age [18].

However, Cherkashin et al, had suggested using a special combined 3-minute test to assess the functional ability of athletes practicing Muay Thai. This test was a sequential execution of 9 different combinations of punches and kicks. The number of performed hits had been counted. 40 elite athletes reaching the age 19-22 years old were tested. The test allowed to determine the criteria for special physical and functional fitness for athletes practicing Muay Thai [19]. Zdanovich and Zebzeev had used the special judo fitness test (SJFT) in assessing the level of functionality of 20 elite athletes (17-19 years old) for 1 year. It was revealed that athletes who showed higher SJFT rates at the end of the training cycle they showed higher results of competitive activity [20]. Also, Podrigalo et al, had recommended using a complex method for predicting the level of athletic achievements of athletes based on the analysis of various indicators: physiological, biomechanical, etc. The study involved 17 athletes practicing kickboxing. In the course of the study, indicators of HR recovery were evaluated after the test load and the electrocardiogram readings using the method of Bayevsky. The analysis had identified criteria predicting the likelihood of success in kickboxing [21].

Thus, Russian experts recommend using quantitative indicators of tactical and technical actions of athletes in competitive matches to assess the level of functional fitness of martial artists. Miller and Bakshutov propose to conduct an assessment by filling in a special questionnaire with members of a team or club. The questionnaire must be estimated on a 10-point scale, the volume and intensity of the attacking actions in competitive matches. There are 10 criteria for evaluation. The results of the evaluation for novice athletes on average should not be lower than 15 points, for the elite not lower than 70 points [22]. Osipov et al, have pointed to the possibility of using a number of competitive factors (criteria for the effectiveness of athletes' competitive actions) in assessing the level of physical and functional fitness of elite judo wrestlers [23]. Kuznetsov and Mubarakzyanov [24] confirm that quantitative

indicators of the effectiveness of competitive struggle have significant correlations with indicators of functional readiness (PWC_{170}, HR, maximum oxygen consumption (MOC)).

It is necessary to pay attention to specialists who had used electronic systems of training equipment determining the level of special endurance of athletes. Therefore, Mout'yev and Mishin had used the e-sparring system "Zemita" – training vests, gloves, pillows, equipped with sensors recording the characteristics of the strikes. The equipment was used to determine the optimal indicators of the quantity and quality of strikes among young (6-7 years old) athletes practicing taekwondo. 26 athletes had completed the test - applying the maximum number of hits to the training bag in 60 seconds. The results of the test were used by scientists to create a regulatory base of requirements for the required level of functional readiness of young athletes (at least 85 strokes over 60 seconds) [25]. According to Potapov and Maleev who recommend using the Karbonik breathing simulator (produced in Russia) to increase the level of functional fitness of athletes. The simulator allows you to adjust the concentration of CO2 and O2 during breathing and contributes to the creation of an artificial gas environment (hypoxia-hypercapnia). Studies had been conducted with 20 young (15-16 years old) judo practitioners. Athletes had used the simulator for 20 minutes in a daily training for a month. It was revealed that the use of the Karbonik breathing simulator made it possible to provide an increase in the level of the functional body reserve of athletes. The effect was revealed in the growth of VC indicators, Gench and Shtang samples, decrease in HR at rest [26]. Bukharin et al, had recommended the use of interval hypoxic training in combination with high-frequency impulse electric current (HIEC) to increase the level of efficiency of martial artists. Scientists had investigated the effect of interval hypoxic training with HIEC of elite wrestlers (n=10) of the Greco-Roman style. Age of athletes - 18-21 years. The course of exposure - 15 days (daily workouts with HIEC). At the end of the course, an increase in the figure of aerobic productivity (PWC_{170} test) and the body's resistance to hypoxia (Gench test) was revealed [27]. Roguleva had used the method of transcranial stimulation of the brain by pulse current to optimize the functional status of athletes. The study had involved 13 elite wrestlers reaching the age 18-24 years. The course of transcranial stimulation consisted of 10 daily sessions (the duration of each was 20 minutes). The sessions were conducted using the TRANSAIR-5 device (production - Russia) the maximum value of the pulsed bipolar current was 3 mA. The scientist argues that such a course helps to optimize the functional state of the nervous system, increase the speed of simple and complex sensorimotor reactions, synchronize the electroencephalogram rhythms of athletes [28]. Gorbachev had conducted a study with elite wrestlers of Greco-Roman style dedicated to the ability to control muscle activity on the parameters of the envelope electromyogram based on the principles of biofeedback. The use of the electromyogram envelope in training the biceps and triceps muscles of the shoulder had increased the adaptive capacity of the cardiovascular system of athletes to special training loads by 10-12% [29].

According to Terzi who recommends the use of diagnostic control methods to optimize the process of functional readiness of martial artists successfully. The scientist had used a number of functional tests to determine the level of functional readiness of athletes (n=50) of various qualifications practicing taekwondo. There are recommended samples: Gench, Shtang, Ruffer, Cerdo, Skibinski and others. Terzi believes that the complex of functional tests is an informative method for assessing the effectiveness of the training process aimed at forming a high level of functional fitness [30]. Korzhenevsky et al, had used the PWC_{170} test and a special force test (lifting the barbell of the bar – 20 kg, the maximum number of times) for complex diagnostics of wrestlers of Greco-Roman style. Besides, 57 wrestlers had passed the diagnosis: 10 elite athletes and 47 young athletes. At the same time, age of athletes - 16-26 years. The use of these tests allowed scientists to develop uniform criteria for assessing the functional readiness of wrestlers of various levels and ages. In particular, it was revealed that the HR recovery indicators in the PWC_{170} test in 3 minutes after the load should not exceed 108±0,9 beats/min. for elite athletes. HR recovery rates of young athletes should not exceed 116±1,3 beats per minute. In the strength test, the average time for lifting the rod is 5,00±0,2 minutes for elite wrestlers and 3,15±0,2 min. for young athletes [31]. Laptev had conducted a study with 45 elite Greco-Roman wrestlers to determine the maximum aerobic capacity of athletes. For testing, a test with increasing load was performed on the “Monark Peak Bike 894E” bicycle ergometer. Besides, the power of work performed at the level of the anaerobic threshold had been evaluated. The mean values of the lungs for athletes – 162,7±8,9 W, average ones – 191,6±7,1 W and heavy weight categories – 217,8±15,7 W had been found. The scientist suggests using the obtained data to evaluate aerobic efficiency of athletes [32]. Volodchenko et al, had proposed to use a whole battery of psychophysiological tests that assess the speed of athletic reactions of athletes for a qualitative assessment of the functional status of martial artists. The study had involved 76 elite athletes practicing various types of martial arts. The subjects’ age was 17-21 years old. The test results had showed that athletes practicing kickboxing found better rates of motor reaction speed than athletes practicing other martial arts. However, scientists point out that this set of tests cannot be fully used in monitoring the functional status of athletes since the battery of tests they offer is far from complete [33]. Simakov and Pavlov had determined the functionality of young athletes (14-18 years old) practicing taekwondo. Gench test and Harvard step test had been used. According to an obtained data, the integral health indicator was calculated. Scientists say that athletes who have the best results of functional fitness the working efficiency indicator is 26,9-27,4 units [34]. Ashkinazi and Bavykin had proposed using tests related to speed-strength and strength exercises to assess the level of special endurance of athletes practicing mixed martial arts (MMA). Young athletes (16-18 years old) had taken part in the research. The athletes had performed the tests: squats with a barbell on the shoulders (70% weight of the maximum) to failure and performing movements – 2 hand strokes + throw (1 min.). After the exercise, HP indicators with 1.2.3

minutes' intervals of athletes had been recorded. It was revealed that athletes with a higher level of functional fitness demonstrate significantly (P <0,01) higher values of the proposed tests results [35].

Indeed, some scientists propose to use methods of biochemical control to assess the level of functional fitness of martial artists. Kuznietsov and Kurov had conducted research with elite judo wrestlers (n=30) reaching the age of 18 to 28 years old. Athletes had performed an intense load, close to the competitive (test match). 5 minutes after the load was completed, blood and urine were collected to determine the level of creatine, creatinine and urea. Moreover, athletes who had a high level of functional training, the level of creatine and creatinine in the blood had increased but then it had decreased during the recovery period (day). Judoists with a low level of functional readiness had showed an increased concentration of creatine and creatinine in the recovery period [36]. Korzhenevsky et al, had investigated 20 elite wrestlers of Greco-Roman style during the pre-competitive preparation period. Scientists investigated the lactate concentration in the blood of combatants. Analysis had been made in 3 minutes of active struggle. Based on the analysis, 3 different types of adaptation of athletes to competitive loads had been identified. The best type was the presence of medium changes in the concentration of lactate in the blood from the normal 15-16 mmol/l (22-23 mmol/l). It was proposed to use the indicators of athletes as selection criteria for the formation of national teams [37]. Also, Sashenkov et al, had investigated the features of peripheral "red" blood in beginners and elite athletes (n=204) practicing boxing and various types of wrestling. It was revealed that wrestlers regardless of their qualification had showed that "red" blood did not differ significantly. The boxers had found significant differences in the peripheral blood indices depending on the level of athletic achievements of the athletes. A significantly higher content of reticulocytes in the blood had been found among the athletes with lower qualifications. Besides, the volume and diameter of erythrocytes and hemoglobin in the blood were significantly higher among elite boxers [38]. Isaev et al, had investigated the immune status of elite wrestlers (there are 41 wrestlers and 29 boxers) using the Novikov method. Neutrophil secretion activity, lysosomal activity parameters and levels of the main types of immunoglobulins were determined in the serum of athletes. The obtained values allow us to determine the level of functional readiness of athletes since there is a significant load on the immune status of martial arts which affects their working efficiency in martial arts significantly [39]. Volodchenko et al, had used the saliva analysis of kickboxing athletes to determine the general state of martial arts. Saliva sampling was carried out before and 5 minutes after the training session. The indicators of glycolysis, the level of lactic acid concentration, the degree of lipid oxidation, etc. had been investigated. The obtained biochemical indicators were informative criteria for assessing the degree of training load on the body of athletes [40]. Pseunok et al, had investigated young (11-13 years old) sambo fighters by photocolorimetric method. Saliva had been collected to determine the concentration of K + and Na + ions. The study period was during 5 months. It was revealed that with excessive training load, the level of K + and Na + ions in the saliva of young athletes had been significantly increased. An excessive increase serves as a signal of the need to reduce training loads in these indicators [41].

Furthermore, Kalnitskaya et al, had investigated 10 elite athletes practicing judo using the Gas Discharge Visualization (GDV-gram) method. GDV-grams of all fingers of both hands of the athletes were recorded with the help of the device "Quantum-Pro" for 10 seconds. Scientists say that athletes with a higher level of functional readiness have a much larger GDV-grams glow area than judoists with a lower level of functional training [42].

In some studies, focusing on the methods of monitoring the functional status of martial artists, interesting data were found on the possibility of effective recovery of the body of athletes with significant loads. The data of the increase in the functional capabilities of the body of combat sportsmen are presented by the use of food additives and sports nutrition. Shustov et al, had pointed to the possibility of a significant increase in the physical endurance of the martial arts using the multi-component food complex "Attack". This complex consists of three modules combining concentrated protein food supplements with extracts of medicinal plants (ginseng, lemongrass, mint, etc.). In the course of research with a group of elite martial artists (n=20), a significant increase of the athletes' functional parameters was revealed: recovery time after the test load, speed of visual-motor reactions, etc. and in 4 weeks of regular intake of this food complex [43]. Gavril'eva had developed a way to restore the body of young athletes (16-17 years old) engaged in free-style wrestling as a natural biological remedy - antler mass of reindeer. It was revealed that regular use of antler mass during the pre-competition preparation leads to an increase in the level of hemoglobin in the blood, an increase in the level of testosterone and a decrease in the level of cortisol. The course application of antler weight contributes to a more rapid recovery of body functions of young athletes [44]. The practical significance of such studies is high since there is an increase in the use of sports nutrition and phyto-drinks among young athletes and young people who start playing professional sports in Russia [45]. The use of effective methods to restore the functional state of young athletes is necessary since modern sports activities are characterized by a fairly significant amount of training and competitive loads.

DISCUSSION AND CONCLUSION

Consequently, an analysis of the findings revealed that most methods for monitoring the functional status of athletes used by Russian scientists are also relevant for foreign specialists. The main methods for assessing the load perceived by athletes: physiological (blood lactate, heart rate) and special tests (SJFT, etc.) are also widely used by sports doctors and specialists around the world [46]. It should be noted that Russian scientists offer different values of lactate concentration in the blood as a criterion for assessing the functional readiness of athletes. The range of values from 22,7 mmol/l [13] to 24,8 mmol/l [17] was revealed. However, the difference between the presented

values is not critical. Also, many factors could have influenced the obtained values: precompetitive preparation, weight reduction, specificity of the type of struggle, etc. Therefore, in our opinion, it is permissible to assess the level of functional readiness of martial artists by the presented values. It should be noted that biochemical indicators of the response of athletes to the load are presented by evaluating the reactions of lactate in studies [37], the concentration of various substances in saliva [41], other indicators are not studied enough. Foreign scientists point to the need for additional extensive study of various biochemical reactions of athletes during training and competitive load [47].

It was found that Russian specialists use different methods for analyzing the heart rhythm of athletes when evaluating the response to exercise. Thus, many scientists use the method of Bayevsky [13; 16; 21] proposing to assess the adaptation potential of athletes by the frequency of the R-R ECG intervals. Other specialists use ECG recording method of Dushanin [17]. This method is based on the analysis of the average amplitude of the R and S teeth in leads RV2, RV3 and RV6. Another method for assessing the adaptation potential of martial artists is ECG recording method of Zavyalov. The method involves determining the number of ischemic ST segments as a percentage of the ECG complexes presented for the study. This method is widely used specifically in martial arts [14; 15]. Therefore, we are not ready to give preference to one or another method of assessing the body's response to stress since all the mentioned methods in the review are widely used in the practice of sports medicine and have positive feedback from specialists. In the future, we can conduct a comparative analysis of the accuracy of these methods which will be the subject of further research by scientists.

Moreover, the lack of comprehensive research on the adaptation of young athletes to intense training effects. At the same time, it was found that the adaptation potential of young and novice athletes was significantly lower (almost 2 times) than that of elite wrestlers [4]. Comprehensive studies are needed to increase the adaptive capacity of young martial artists to an ever-increasing amount of training effects. Experts say that the control of training load and physiological recovery between training sessions is an important aspect for planning the periodization of training and increasing the level of athletes' competitive readiness [48].

There is a lack of comprehensive scientific research on the monitoring of the functional status of athletes in the long preparation stages. The duration of many studies is insignificant (no more than 2-3 weeks) and characterizes the functional status of athletes in the period of preparation for significant competitions. Longer periods of monitoring are needed which characterize the different stages of training martial artists as indicated by experts [6]. Also a lack of data on the development of the adaptive capacity of women practicing martial arts has been revealed. There are no data on mature athletes (30 years and older). It can be recognized that in recent years, the priority direction of research by Russian scientists has been the optimization of the training activities of young (17-22 years old) elite male athletes who can be the members of the national teams of the Russian Federation and other CIS countries.

Nevertheless, a number of Russian scientists apply quantitative indicators of technical and tactical actions of athletes in competitive matches to assess the level of special physical and functional readiness of martial arts [22; 23]. These methods do not refer to objective methods of monitoring the functional status of athletes, but can be used in conjunction with other methods of assessing the functional state of martial artists. Correlations between the level of competitive achievements and the functional state of athletes practicing martial arts are confirmed by both Russian [24] and foreign scientists [49].

It was revealed that the majority of research results Russian specialists publish in national scientific journals [50] issued for a fairly narrow circle of Russian-speaking specialists: coaches, doctors and scientists. Identified a lack of publications in journals of international scientific citation bases: Web of Science, PubMed, SCOPUS. The lack of citations of significant scientific works of foreign experts is also found in most of the discovered publications. Unfortunately, it can be assumed that the lack of scientific information will negatively affect the quality of research by Russian specialists. The absence or lack of modern and accurate data will not contribute to improving the quality of the process of preparing athletes for competitive activities.

In conclusion, we may say that the review authors expect that the provided information will help improving the quality of training activities in martial arts aimed at achieving high results in sports and preserving the physical health of athletes. The relevance of the data presented is due to some lack of modern scientific information about the methods of qualitative monitoring of the functional status of athletes and a significant increase in the volume of training loads in martial arts.

ACKNOWLEDGEMENT

The authors would like to thank the subjects who participated in this study.

Conflicts of interest

If the authors have any conflicts of interest to declare.

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